

A High-Penetration, Wind-Diesel Hybrid Power System

by Steve Drouilhet 12/99

Background

Alaska has approximately 250 rural villages with no link to a central power grid. A few of these villages have no central electric generating facility; however, the vast majority are served by diesel-driven generators and local electric distribution systems. Despite Alaska's vast crude oil resource, diesel fuel must be imported by barge because most of the villages are extremely remote and there are few good roads. The great distances and difficult transport conditions result in diesel fuel that costs from \$0.80 to \$3.00 per gallon delivered. The high fuel cost and high operations and maintenance costs of diesel generating stations add up to electricity generation costs ranging from \$0.15 to \$1.00/kilowatt-hour (kWh) for the villages.

To ease the energy cost burden on rural inhabitants, Alaska's Department of Community and Regional Affairs (DCRA) administers the Power Cost Equalization Program (PCE), which provides a subsidy to rural electric customers as high as \$0.41/kWh and totals nearly \$20 million annually. Because of declining Alaskan pipeline oil revenues, the fund from which they derived the PCE subsidy payments, is expected to be depleted in approximately six years. To stave off a rural energy crisis, the state of Alaska is urgently seeking to develop alternatives and supplements to diesel for both electricity generation and heating fuel.

Besides the economic problems associated with diesel use, there are significant environmental problems associated with the fuel. Because many ports along the coast and along the interior rivers are accessible only a few months out of the year, large quantities of diesel must be stored on-site in bulk fuel tanks. Many rural village tank farms have deteriorated with age and are leaking, contaminating surrounding soil. U.S. Environmental Protection Agency (EPA) regulations

threaten many village tank farms with closure. The DCRA estimates that it would cost \$200 million to upgrade existing diesel tank farms to today's standards, not including the cost of environmental remediation.

Beyond the looming fuel storage and transport problems, diesel operation introduces substantial noise and air pollution into the village environment. Use of renewable energy for electricity generation will mitigate fuel transport and storage problems and reduce the pollution and noise associated with diesel fuel consumption.

The rural power situation in Alaska is similar to that of many developing countries around the world, where rural electricity, if it exists at all, is provided by small, isolated diesel power plants. Alaska can serve as a domestic proving ground for U.S. industry in using renewable energy solutions to bring power to remote communities worldwide.

Project Objectives

The project staff will design, build, install, and test a high-penetration wind-diesel system in Wales, Alaska. Wales is a small village on the northwest coast of Alaska with approximately 160 inhabitants, mostly Inupiat Eskimo. Alaska Village Electric Cooperatives (AVEC) will operate the system as the host utility and the Kotzebue Electric Association (KEA) will own and maintain the system. They will integrate the new components of the power generation system (wind turbines, power conditioning, energy storage, and a control system) with the existing diesel system, which has an installed capacity of approximately 360 kW. In addition to electricity generation, the project will show the effective use of community heating loads to absorb excess wind energy and maintain grid stability.

We expect the hybrid system to consume 50%–60% less fuel than the current diesel plant, with additional savings coming from the application of excess wind energy to village heating needs. The Wales project will be a prototype to validate the technical feasibility and economic viability of high-penetration wind-diesel hybrid electric generation systems for applications in other rural villages, both in Alaska and in various international locations.

Project Funding

The Wales wind-diesel project has an overall budget of approximately \$1.2 million, with major funding provided by the U.S. Department of Energy, the EPA, and the Alaska Science and Technology Foundation. Additional contributors include the Alaska Department of Community and Regional Affairs Division of Energy, Kotzebue Electric Association, and the Alaska Village Electric Cooperatives.

Planned Activities

Assembly of the system was completed in July 1998 at the Hybrid Power Test Facility at the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center. System operation was successfully demonstrated in the simpler operating modes, in which the wind turbines operate in parallel with the diesel generators, and the diesel generators regulate system frequency and voltage. The more advanced operating modes, which involve the energy storage component and allow the generators to be turned off completely, were successfully demonstrated in November 1999. The complete wind-diesel controls package is scheduled for shipment to Wales, Alaska, in spring of 2000. Installation, start-up, and commissioning will occur during the summer of 2000. Before the package arrives, KEA and AVEC personnel will be working to install the wind turbines, convert the village power plant from single-phase to three-phase, install electric resistance heaters in several village heating systems (for use as secondary loads), and upgrade the existing diesel controls for automatic operation.

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